The Observation of Water Compartmentalization In-Vivo in the Feline Lumbar Spinal Cord

D. Hallihan1, A. Yahya1, K. Wachowicz1, C. Hanstock1, V. K. Mushahwar1, P. S. Allen1

1University of Alberta, Edmonton, Alberta, Canada

Synopsis
The overall goal of this project is to develop NMR techniques for in-vivo assessment of spinal cord pathology after injury. In the present study, in-vivo transverse relaxation measurements of the feline cord were obtained from spin echo images by selecting individual ROIs in each of the grey or white matter and applying non-negative least squares analysis to fit the transverse decay in each ROI. White matter returned a unique component at ~20 ms corresponding to myelin water, whereas both the grey and white matter displayed components from axonal and extra-cellular water between 50 ms and 100 ms.

Introduction
Transverse relaxation measurements have been conducted in-vivo on the spinal cord of a cat, the cat being an excellent model of spinal cord injury. The objective of the study was to develop methods for distinguishing pathology in the cord following injury.

Methods
All experiments were performed within an 80 cm bore, 3T magnet (Magnex) used in conjunction with a SMIS spectrometer console. An r.f. surface coil was constructed on form-fitting plastic and measured 16 cm by 8 cm when flat. Anesthesia in cats was induced and maintained with intra-muscular injections of KAR mixture (Ketamine 18.7 mg/kg, Atropine 0.03 mg/kg, and Rompum 0.38 mg/kg). The tailored surface coil was used to obtain 13 transverse, spin echo images of the lumbar enlargement of the cat’s spinal cord, with echo times varying from 7ms to 600ms. All image sequences had the following parameters: TR = 2 s, FOV = 120 mm, slice thickness = 3 mm and acquisition matrix = 256x256. Using non-negative least squares (NNLS) analysis [1], T2 spectra were obtained first from a 4x4 pixel box located in the body of the grey matter, and then from a 4x4 pixel box located in the white matter.

Results
Figure 1 shows a transverse gradient echo image of the feline cord taken with the tailored surface coil. The contrast between grey and white matter in the cord is clearly visible. Figure 2 illustrates the T2 spectra obtained from the two 4x4 pixel boxes from one of the cats. The second cat showed similar T2 spectra. In the grey matter only a single component could be detected, whereas in the white matter box two components were returned. Both grey and white matter have one component between 50 ms and 100 ms and white matter has a second component near 20 ms. The compartment unique to white matter (labeled 1 in Fig. 2) has a T2 value consistent with the component assigned to myelin water in many studies of excised nerve [2]. The overlapping compartment between T2 ~50 ms and ~100 ms represent axonal and extra-cellular water, but on the basis of these preliminary data specific assignments cannot be made.

Conclusion
Using an anatomically tailored r.f. surface coil it is possible to determine non-invasively the transverse relaxation components from various compartments of the cord. This provides an opportunity for assessing the status of spinal tissue after injury and following rehabilitation interventions.

Figure 1: In-vivo gradient echo image, TE = 25 ms, TR = 800 ms, acquisition matrix = 512x512, FOV = 160 mm.

Figure 2: Signal decay curve above, corresponding T2 spectra below.

References

Acknowledgments
The authors would like to thank the Canadian Institute of Health Research for their generous funding.